Risk perceptions of dust and its impacts among communities living in a mining area of the Witwatersrand, South Africa

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Mining is a major economic activity in many developing countries. In South Africa, gold mining has played a significant role in the development and sustenance of the country's economy, with both positive and negative consequences. In gold mining areas, tailings dams and mine dumps are significant sources of ambient dust, known to be a nuisance, and health risk, to communities living near them and who must find appropriate coping mechanisms to protect themselves. A qualitative study based on five focus groups with sixty-two participants of different ages and sex was carried out in the Witwatersrand mining district of South Africa. All focus groups agreed that they had noticed dust in the air where they live, stating that the dust came largely from mine dumps but also from other sources. They agreed that the dust causes, among others, health problems, and both short-term and long-term coping mechanisms for protecting themselves against excess dust were mentioned yet considered inadequate, i.e. closing windows and doors, watering their yards, paving their yards and planting trees. Little support from government, mines and other organisations was identified as an important perceived barrier to resolving the dust problem. Means for communication of communities' perceptions of the impacts, risks and possible mitigation / adaption measures associated with dust need to be created and supported in a formal risk management plan.

Keywords: community perceptions, mining impacts, mine dust, health

1 Introduction

Mining is a major economic activity in many developing countries. Mining operations may be disruptive to the environment and have potentially adverse impacts on communities located in close proximity to such operations. In South Africa, mining, specifically gold mining has played a significant role in the development and sustenance of the country's economy, with both positive and negative consequences. The Witwatersrand gold rush started in 1886 and since then, more than 50 thousand tonnes of gold has been recovered. By 2010, there were nearly 300 tailings dams (i.e. an industrial waste dam for mining waste or the materials left after the fraction that has any value had been removed) in the Witwatersrand area.[1] Gold mine tailings generally comprise heavy metals, e.g. zinc, copper, lead and arsenic, chemicals used during the milling processes, and other toxic material including cyanide and the radioactive uranium.[2] Heavy metals are associated with neurological, cardiovascular and respiratory effects, while uranium is associated with kidney damage.[3]

The gold mine dumps and tailings dams were and still are sources of air pollution as many of them are not covered. Communities, such as Davidsonville, Kagiso and Krugersdorp, living in the Witwatersrand area (Gauteng Province) live alongside these gold mine dumps and tailings dams. Many of these communities comprise historically marginalised ethnic groups living in government-funded houses, informal settlements and retirement homes. Evidence suggests that these mine dumps and tailings dams are a dust nuisance for the local communities during periods of high winds. This suggests multiple exposure pathways (i.e. breathing, drinking, eating and dermal contact) for local communities who complain of the general deterioration of their health. Respiratory problems are a major concern.

Therefore, it was considered important to understand the individual and collective perceptions of mine dust risk among the potentially vulnerable communities living in the Witwatersrand for risk management planning – the aim of the study. The objectives of this study were to analyse how the communities perceive mine dust, when dust is most prevalent, possible human health and nuisance impacts felt by the communities, to help identify possible readily-implementable coping mechanisms against these adverse impacts. The working hypothesis that guided the study was that communities exposed to mine dust perceive themselves to be impacted in negative ways. While similar studies have been reported in Mexico[4], Tanzania[5], Ghana[6] and Australia[7], to the best of the authors' knowledge, this is the first formal documentation of public perceptions regarding mine dust in a mining hotspot in South Africa.

2 Methods

2.1 Study design and study area

The study design was qualitative and based on responses to an interview guide posed during focus group discussions at a meeting held on the 14 April 2012 in Krugersdorp, Mogale City Local Municipality (MCLM). This town was identified as the study area by talking to ward committee members and the local municipality and based upon its close proximity to mines; abandoned mines and mine tailings dams are located in the area.

The objective of the focus group discussions was to

obtain collective responses to eight questions about dust and its impacts. This article presents the results of the focus groups' responses. Ethical clearance for this study was obtained from the CSIR Research Ethics Committee on the 10 August 2011 (Certificate Number: REF 20/2011).

For discussion purposes, air quality monitoring data were obtained from the MCLM and analysed to understand ambient air quality, in particular, particulate matter (PM), the solid and aerosol fraction of air pollution (Report presented to the MCLM in 2012, prepared by and available from the CSIR). Results were compared with the South African National Ambient Air Quality Standards.

2.2 Procedures

A pre-meeting was arranged with the MCLM ward committee members in March 2012 prior to the public meeting of the 14th April 2012 in order for them to understand what the study entailed. During this meeting, ward committee members were given a presentation about the study and their questions were answered. Due to logistical challenges, it was agreed at the pre-meeting that ward committee members would attend the planned meeting as representatives of the local communities. Hence, purposeful convenience sampling was applied.

The meeting was held on the 14th of April 2012 in the Krugersdorp town hall for a period of three and a half hours from 11h00 to 14h30. The MCLM provided a minibus taxi to transport participants from their respective suburbs, which ensured increased participation.

The meeting entailed delivering opening remarks, a presentation to brief the participants of the intentions of the meeting and to provide them with an understanding of the study. Thereafter, verbal consent, as agreed upon by the CSIR Research Ethics Committee, to participate was obtained from all meeting attendees.

A focus group breakaway session was then held where participants were organised strategically into five focus groups to discuss their perceptions and experiences concerning dust. There were five facilitators who were trained by the project investigator using a set of notes from a training manual and briefed prior to the public meeting and they followed a discussion guide for facilitation of each focus group. Meeting participants were divided into five groups averaging 10 to 13 people per group (as small as we were able to provide for, however, this may have been a limitation given the time available for participants to present their thoughts). The focus group discussions were done in local languages and lasted for 90 minutes. The facilitator recorded all participants' responses to each question using paper and notes kept, and these responses were later transcribed using formal transcription conventions.

Each focus group was asked to select a rapporteur who reported back on the groups' deliberations of the eight questions posed in the interview guide (discussed below). In some cases, the rapporteur was the facilitator and in other cases it was a focus group participant. A report back session lasted for a period of 40 minutes.

2.3 Interview Guide

A structured interview guide comprising eight questions was used in a focus group setting. Facilitators led a discussion around each open-ended question / topic. Specific questions / topics were: (1) Have you noticed dust in the air before; (2) Where do you think the dust you see comes from; (3) Has the amount of dust in the air changed over the past five years and is it different in winter compared to summer; (4) In your experience, what is the biggest source of dust; (5) Do you or anyone in your family ever go near the mine dumps (tailings dams); (6) Is the dust ever a nuisance to you and in what ways; (7) How do you protect yourself from mine dust; and (8) Anything else you'd like to comment on about dust in your area? The order in which the questions were addressed applied the funnel technique to assure that the participants were put at ease, interest was generated, and to ensure that the participants were willing to share their dust experiences in more detail.

2.4 Data processing and analysis

Responses to the questions posed during the focus group discussions were recorded by the facilitator and transferred to Microsoft Excel spreadsheets after the meeting. Two data enterers checked the original focus group discussion notes and the electronic data to ensure consistency and accuracy of electronic response recording.

Data analysis was performed using a validated method of analysing data from focus group discussions. This method included a complete and repeated reading of the transcripts, identifying emerging themes, developing categories based on those themes, coding the data and separating the data according to categories for data interpretation.

Focus group responses were captured individually by question; except for responses to questions (2) and (4), which asked similar questions about the likely dust sources differing only by asking for the biggest dust source in question (4). In question (4) most participants gave more than one source, hence the responses to these two questions were combined. Therefore, the responses to five questions are given in Table 1.

Electronic responses were then searched for common themes and when such commonalities were found, a single term was used to describe the comment. This was done for ease of tabulating similar responses and to identify common perceptions. No responses were discarded to ensure

all focus group participants' perceptions were included for analysis and interpretation.

3 Results

A total of 62 participants comprising ward committee members (themselves community members) from the suburbs in and around Krugersdorp attended the public meeting. The total number of ward committee members in MCLM is 340, hence 18% attended and represented the views of the wards for which they are responsible in MCLM. Table I gives the results of the five focus group discussions for five of the eight questions in the interview guide.

|While we did not in any way plan for consensus among the group discussions, in many instances participants of a focus group did agree. All focus groups (100%) agreed that they had noticed dust in the air where they live. One participant was noted as saying, "*'Dust is a big problem in our communities. It's everywhere - we breathe it, we eat it, we drink it - even our animals are not safe from the dust. Everybody is affected*". With regard to sources of the dust, all of the focus groups said the dust came from mine dumps and three groups said from sandblasting. Other sources mentioned included roads, open fields, coal yards, brick-making and motorbike racing.

The majority of the focus groups (n = 3) said the amount of dust had changed, specifically increased, over the past 5 years, and two groups said it had not changed. Two thirds of the focus groups said that dust is different in summer compared to winter. They explained that in summer the dust is less due to rain and in winter it is more because it is drier and windy. In addition, one focus group said that the amount of dust is the same throughout all the seasons and they attributed this to climate change.

Mine dumps were identified as the biggest source of dust by 55.6% of the focus groups, 22.2% stated sandblasting, 11.1% stated coal yards and 11.1% stated the dry season. All of the focus groups agreed that they go near mine dumps because their homes are in close proximity to them and some focus group participants mentioned that their children use the mine dumps as playgrounds, as indicated "*'We get sick when we breathe this dust. It's worse for our young children who play near the mine dumps*" (Partipant of Focus Group).

All focus groups agreed that dust is nuisance to them. With regard to how dust is a nuisance to them, the focus groups said it causes health problems, it damages furniture and electrical appliances, and it contaminates water. In addition, dust was identified as affecting animal life, soil, the environment in general, and food. Focus group participants mentioned similar short- and long-term coping mechanisms for protecting themselves against excess dust, including closing windows doors and air vents, and watering their yards, and paving their yards and planting trees, respectively. Only one focus group said they do not protect themselves in any way against dust.

The final topic of the interview guide was an open-ended question asking for any additional comments about dust. Focus group participants commented that the government should search for the perpetrators who abandoned the mine dumps to resolve the dust problems they had created and that the government must intervene by providing medical assistance for ill health caused by exposure to mine dust. A participant was noted as saying, "*The government has to help us solve this dust problem*".

Mine owners were also identified as responsible for removing and / or rehabilitating the mine dumps and tailings dams: ("*The mining companies, even the ones that are no longer here, have to take responsibility and help us solve this problem*" – Focus Group Participant)

Relocation of homes was mentioned as a possible solution to the impact of dust on communities currently living in close proximity to mine dumps. A need to carry out research on what chemicals the dust in the air contains and the likely health implications thereof was also noted.

Air quality monitoring data were obtained and analysed to understand ambient air quality, in particular, particulate matter (PM), the solid and aerosol fraction of air pollution (Report presented to the MCLM in 2012, prepared by and available from the CSIR). Monitored data for PM mass concentration with a diameter equal to or less than 10 micrometre (PM_{10}) were compared to the South African National Ambient Air Quality Standards[9] (Table II). Although air quality data capture was only 70% during the period, the results indicated that for 1 August 2010 to 15 September 2010, the current national 24-hour standard of 120 µg/m^3 for PM_{10} was not exceeded. The highest 24-hour average mass concentration measured was 98 µg/m^3. However, the proposed South African standard of 75 µg/m^3 (that will come into effect on 1 January 2015) was exceeded on seven days during this period. PM_{10} data for October 2010 were incomplete due to power failures but showed four exceedences of the current standard, with a maximum concentration of 145 µg/m^3. These data confirm that ambient dust levels (focusing on PM_{10}) at Leratong (used as a proxy for a much wider affected area) were relatively high, particularly when compared to the proposed 2015 National Ambient Air Quality Standard that will be set to protect human health.

4 Discussion and recommendations

Gold mining used to be the core of the MCLM's economy until several mines were closed and tourism, manufacturing and agribusiness took precedence. Mine closure was accompanied by a lack of rehabilitation of mine dumps and tailings dam resulting in environmental and human impacts,

including those related to dust emissions. Air pollution sources in the MCLM include dust from mine dumps (that may contain silica and may be radioactive), dust from dirt roads in informal settlements, domestic fuel use (especially wood burning, which is used in the area), veld fires, agricultural activities (dust and pesticides) and illegal dumping of refuse which is often burnt.[8] While wind-blown dust consists mainly of larger particles that may be less of a health risk, it is still considered a nuisance.

By administering focus group discussions with 62 ward committee members living in the study area, it has been affirmed that dust is perceived as a problem and nuisance by residents in the study area, and that residents perceive mine dumps as the largest dust source. While source apportionment has not been carried out for the MCLM, the municipality does monitor ambient air quality at Leratong as part of the Gauteng Department of Agriculture and Rural Development (GDARD) ambient air quality monitoring network. These results, as shown above, validate the participants' perceptions that dust is a problem in their communities.

When compared to previously published studies, our results confirm a common thread: that communities experience dust in a negative way, and that spaces for communication need to be created to listen to communities' concerns and to capacitate them in the risk management plan. This was found among women in Mexico[4] who were exposed to manganese in the mining district of Hidalgo State. This study was also a quantitative study based on 6 focus groups with women of different ages. The integration of different sectors towards finding a solution to dust was discussed in an Australian study[7] that found this process was a struggle, and innovative, site-specific solutions were required. Some of the solutions proposed in a Tanzanian study[5] may be useful in the South African context, namely, reducing illegal mining activity and government providing technical support to local operators and regulations are improved and fully implemented. At the same time, managing expectations of the community relative to what are the roles of government and mining companies is critical as was discussed in Ghana[6].

Several limitations and shortcomings are acknowledged for this study. Ward councilors represented the views of their community members in lieu of the community members themselves attending the meeting. A total of 62 ward committee members, relatively few, participated and a larger sample would have better represented the community. Focus groups were relatively large; however, this was limited by the number of focus group leaders that were available for the meeting (further constrained by the study budget). It would have been better to audio record the focus group discussions, however, this was not cleared by the research ethics committee and limited finances constrained this option.

Short- and long-term coping mechanisms for protecting themselves against excess dust were mentioned by focus group participants. Simple measures such as closing windows and doors, and watering their yards were considered short-term, immediate solutions to protect themselves against dust. However, these were considered inadequate by the participants. They suggested that since dust is an ongoing problem in the study area, longer-term, more permanent solutions are required as part of a risk management plan that requires support from all levels. Participants mentioned some long-term solutions, such as paving their yards and planting trees, but these are costly options and government subsidies may be required to assist with implementation. Additional mitigation strategies identified by community residents included the need for mine dump removal and rehabilitation and possible relocation of communities to less affected areas. Except for the latter, this has been carried out in other parts of the Gauteng Province and should be considered in the MCLM too.

Of foremost importance, given the communities' perceptions of dust and its impacts, is a formal mechanism for communicating their concerns of dust impacts, risks and viable mitigation / adaption measures to government and other agencies, supported by appropriate policy and a risk management plan. Community participation by residents and ward committee members, as well as other local leaders, and support from all spheres of government, in the risk management planning is essential. The management of community risks posed by dust, including health risks, damage to property, animals and general nuisance in the MCLM and South Africa as a whole cannot be effective unless it is planned, developed and implemented by all relevant stakeholders and role players, including the communities themselves. It is important that such risk management plans are informed by appropriate studies. Studies that may be beneficial in order to develop such plans would aim to gain a better understanding of the types of mine dust and its constituents, the extent of exposure and associated health impacts, and how coping mechanisms can be improved to ensure optimal protection for the communities from the dust.

5 Conclusions

Ward committee members representing MCLM communities living near gold mine dumps and tailings dams in the Witwatersrand area of the Gauteng Province, perceived that local communities are exposed to excessive amounts of dust mainly from mine dumps and tailings dams. The ward committee members expressed that the dust problem has not improved in the past five years, but that it is getting worse. The 62 ward committee members, who participated in focus group discussions, were in agreement that the dust is not merely a nuisance, damaging their appliances and contaminating their food, but that it is also having an adverse effect on their health. Very limited air quality monitored data, which showed relatively high dust concentrations,

suggest that this perception may potentially be true.

The ward committee members further expressed that, communities' short-term measures adopted to cope with the dust, and to reduce the impacts, such as watering their yards and closing doors and windows, do not seem to be effective. Even more permanent action, such as paving their yards, which has a cost implication for residents, did not solve the problem.

The ward committee members indicated that a more permanent solution to the dust problem needs to be found, and that all relevant stakeholders including government and mining houses and communities need to work together in solving the dust issue. A first step towards solving the dust problem may include a risk management plan with a risk communication component. The risk communication platform will provide a means for communicating communities' perceptions of the impacts, risks and possible mitigation / adaption measures associated with dust to authorities. This platform will ensure incorporation of local communities in decision making processes regarding dust mitigation in MCLM.

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7 References

1. Oelofse, S., Hobbs, P., Rascher, J., and Cobbing, J. (2010). The pollution reality of gold mining waste on the Witwatersrand. *RéSource*, vol. 12, 2010. pp. 51-55.

2. Rösner T. and. van Schalkwyk, A. The environmental impact of gold mine tailings footprints in the Johannesburg region, South Africa. *Bulletin of Engineering Geology and the Environment*, vol. 59, 2000. pp. 137-148.

3. Center for Disease Control in the US. [Online] Available http://www.atsdr.cdc.gov/substances/indexAZ.asp (accessed 19 July 2012).

4. Catalan-Vasquez., Riojas-Rodriguez, H., and Pelcastre-Villafuerte, B.E. Risk perception and social participation among women exposed to manganese in the mining district of the state of Hildago, Mexico. *Science of The Total Environment*, vol. 414, 2012. pp. 43-52.

5. Kitula, A.G.N. The environmental and socio economic impacts of mining on local livelihoods in Tanzania: A case study of the Geita District. *Journal of Cleaner Production*, vol. 14, 2006. pp. 405-414.

6. Garvin, T.M., Tara K.M., Smoyer-Tomic, K.E. and Aubynn, E.A. Community–company relations in gold mining in Ghana. *Journal of Environmental Management*, vol. 90, 2009. pp. 571-586.

7. Higginbotham, N., Freeman, S., Connor, L., and Albrecht, G. Environmental injustice and air pollution in coal affected communities, Hunter Valley, Australia. *Health & Place*, vol. 16, 2010. pp 259-266.

8. State of the Environment Report - Mogale City. [Online] Available: http://www.environment.gov.za/soer/reports/Mogale%202003/air_quality.pdf (Accessed 27 February 2012).

9. Department of Environmental Affairs. Government Notice No 1210, Government Gazette No. 32816, 24 December 2009.

Table I: Community perceptions of dust sources, quantity, its impacts and possible coping mechanisms by focus group

Topic	Focus group 1	Focus group 2	Focus group 3	Focus group 4	Focus group 5
Source of dust	Mine dumps, sand blasting, coal yards	Mine dumps, roads, sandblasting	Mine dumps, brick making, sandblasting	Mine dumps, open fields, roads	Sandblasting, mine dumps, motorbike racing
Amount of dust in the air changed over the past 5 years	No	Yes Increased	Yes Increased	No	Yes Increased
Amount of dust different in winter compared to summer	Winter- more dust, drier, windy Summer-less dust because of rain	Winter-more Summer-less	Winter-more dust, drier and windy Summer-less dust because of rain Autumn-more dust, wind	Winter-more Summer-less	It is the same in all seasons
How is dust a nuisance	It causes health problems, damages furniture and electrical appliances	It causes health problems and contaminates water	It causes health problems, contaminates food , damages furniture and electrical appliances	It causes health problems, affects animal life, soil and electrical appliances	It affects the environment, health problems and damages furniture
Ways to protect against dust	Close windows and doors	No way of protecting against dust impacts	Planting of trees, close the windows and doors, paving and watering the yard	Plant trees and grass	Close windows and doors

Table II: South African National Air Quality Standards for PM

Pollutant	Averaging Period	Limit Value ($\mu g/m^3$)	Frequency of exceedance	Compliance date
Particulate Matter (PM_{10})	24-hour	120	4	Immediate - 31 December 2014
	24 -hour	75	4	1 January 2015
	Annual average	50	-	Immediate - 31 December 2014
	Annual average	40	-	1 January 2015